# Section 15
# Operations and Planning Overview

## 15.1 Introduction

Unlike previous projects in U.S. human space flight, the International Space Station (ISS) operates on a continuous basis, with execution planning, logistics planning, and on orbit operations occurring simultaneously for long periods of time. Additionally, the sheer size and unique constraints of Station compared to shuttle demand a somewhat different approach to both planning and operations.

The ISS planning process is very complex and involves many interfaces and products. Utilizing the results of this planning process for operations as well as translating the results of current operations into future planning is a sophisticated process. This section introduces the overall process and introduces several products and activities of each of the four phases of ISS planning that are important aspects of real time station operations. How these activities are performed on orbit is also described. Everyone contributes a piece of this puzzle and requires other parts (products) in order to complete their function.

## 15.2 Objectives

After completing this section, you should be able to

- Describe typical products developed during the major mission phases of ISS operations
- Describe the purpose of and activities performed during each phase of the ISS planning process
- Summarize the function of major operations products generated during the planning process

## 15.3 Introduction to Planning Time Frames and Products

### 15.3.1 ISS Planning Time Frames

Before discussing the ISS planning process in depth, it is important to be familiar with the terms that are used to reference planning time frames. These terms are as follows:

- ***Increment (I) - This is the time frame from docking of a vehicle rotating ISS crewmembers to the docking of the next ISS crew.*** The length of an increment ranges anywhere from 1 month to about 6 months. This term refers to all of the activities occurring during the time frame, including the shuttle and Russian logistics flights. Additionally, a great deal of ISS planning is based upon the increment
- ***Expedition - This covers the same time frame as an increment but is used when referring to the ISS crew serving during that increment or their tasks***

- Planning Period (PP) - This is the period on which much of ISS planning is based. It spans approximately 1 calendar year but is tied to the beginning and end of ISS increments, so usually does not begin on January 1. PP 1 is June 1998 through January 1999 and includes Increment 0 (Flights 1A/R, 2A, 1R, 2A.1, 3A). PP 2 runs January 1999 through December 1999 and includes Increments 2 and 3

### 15.3.2 Complexity of the Planning Process

As mentioned in the introduction, the planning process for the ISS is much more complex than that of previous programs. This additional complexity is the rationale for why many of the products described later in this section are produced. There are many factors which make planning for ISS more complex than previous programs, the most important of which are discussed below.

The first is product delivery dates. Some products, such as flight software, are required for every ISS assembly flight at launch (L)-X months. Others, such as the Multilateral Increment Training Plan, are produced for an entire increment (which may include several launches) at I-X months. Since an increment can include several flights, the results are challenges in synchronizing templates and product delivery dates.

The second challenge is international integration. Some of the issues here include language of operations and documentation and merging different cultural styles of planning as well as conforming to memorandums of understanding between international organizations. Just integrating programs is a significant challenge - not only merging International Partner (IP) programs with NASA programs, but also merging the NASA programs (space shuttle and Space Station) themselves. The shuttle program is very stable and is trying to shorten its planning templates, but the Space Station program is very new and is establishing more conservative templates. Shared products under these different styles and priorities for planning are sometimes difficult to schedule together.

The final area that is a particular challenge to ISS is resource management. Crew time, power, communications time and communications bandwidth are just some of the resources that are limited for ISS, and therefore must be managed in order to achieve program objectives of ISS. Many of these resources, such as crew time, also fall under partner allocation agreements made at the program and government level. Planners must ensure that each partner is receiving an appropriate amount of resources over time.

Addressing these challenges is no small task, but the first step is to establish a template for the many product deliveries required to fly the Space Station.

### 15.3.3 Increment Planning Process Template

There are four main phases to planning. They are Strategic Planning, Tactical Planning, Increment Planning and Increment Execution. The phases are not completely distinct because of overlap in some products and early production. Each phase, along with major products produced, are illustrated in Figure 15-1 and described below.

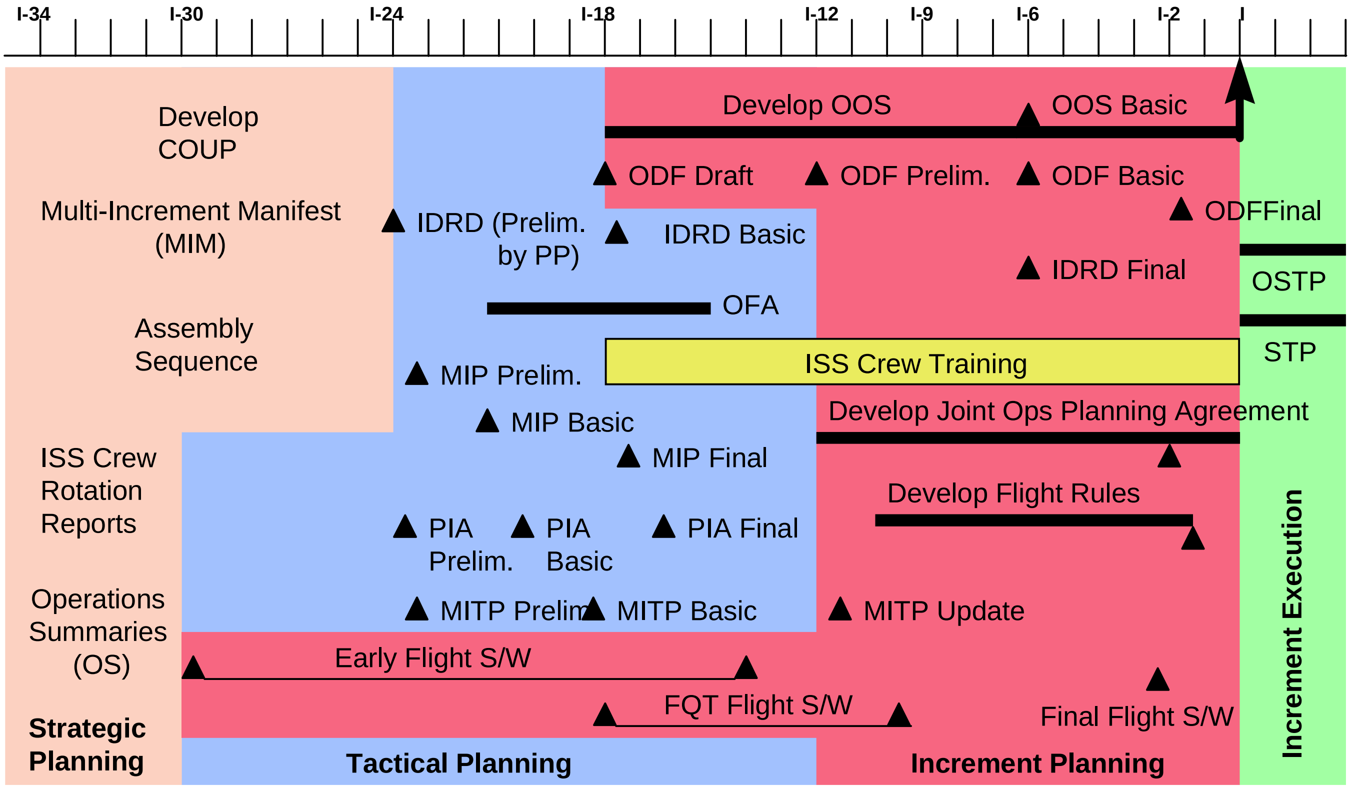


*Figure 15-1. Planning process template*

## 15.3.4 Strategic Planning

Strategic planning is long range planning and begins at about PP-5 years (5 years before a planning period) and continues through I-2 years (2 years before increment execution). Many of the products in this phase are scrolling plans that cover the next 5 years and are updated regularly.

**Consolidated Operations and Utilization Plan (COUP)** - This document is a five year plan for the Space Station. It includes a high level manifest of major items planned for each year and is written by the ISS Program Office.

**Assembly Sequence** - This is essentially the schedule for building the Space Station. It takes into account the system capabilities through the ISS build process, element availability dates and partner agreements.

**Multi-Increment Manifest** - This document is a manifest of major cargo elements covering several planning periods and increments and also serves to document the agreed to crew rotation and vehicle traffic to and from the ISS. It is prepared by the Multi-Increment/Tactical Planning Increment Planning Team (IPT) (an ISS program level group with Mission Operations Directorate (MOD) and IP participation) and signed by all partners. The crew rotation takes into account the upmass capability of the planned vehicle, vehicle life, training currency for time critical and complex tasks, and the assembly sequence. The traffic model for ISS uses the assembly sequence, vehicle life, ISS altitude, logistics requirements and micro-gravity requirements to plan the flow of vehicles to and from the ISS.

### 15.3.5 Tactical Planning

***Tactical Planning begins at about PP-24 months and continues as late as I-6 months. This phase is when plans are laid out for a planning period and each of the increments within that planning period.***

**Increment Definitions Requirements Document (IDRD)** - This document is produced for each planning period. The IDRD serves as an internal program agreement on the requirements for the increments. It is similar to a Shuttle Program Flight Requirements Document. Included in the IDRD are resource allocations, mission priorities, and a detailed manifest for each increment and flight in the planning period. The preliminary IDRD is published at PP-24 months, with the baseline published at PP-18 months and then updated every 6 months as required. It is developed by the Tactical Planning IPT with inputs from all concerned organizations. All affected partners sign the document.

**Resource and Engineering Feasibility Assessments** - Each revision of the IDRD is reviewed by the Mission Operations and Engineering Directorates. The assessment results or impacts are reflected in the next version of the IDRD. This is the opportunity for the planning world to ensure that the priorities and objectives of the increments are possible to achieve.

**Payload Integration Agreement (PIA)** - These documents layout the agreements made between the ISS program and its payload customers. A PIA is produced for each major payload. The agreement includes requirements of each side and resource allocations, including crew time. This agreement will also have a Payload Data Library to document the details concerning telemetry, training, etc. much like Shuttle Payload Integration Plan (PIP) annexes. These agreements are developed by the Payload Operations and Integration Function (POIF) at Marshall Space Flight Center (MSFC).

**Multi-lateral Increment Training Plan (MITP)** - This document is written for each increment. It describes all of the training required to support a single ISS increment including systems and payloads training. There are sections to cover ISS crew training, Shuttle crew training and controller team training. The baselined version is published one month prior to ISS increment specific crew training.

**Mission Integration Plan (MIP)** - This is a Shuttle Program-to-Station Program agreement. It is similar to a shuttle PIP, but covers all of the cargo elements and shuttle-supported activities for an entire ISS assembly or utilization flight. The Shuttle Program Office Payload Integration Manager (PIM) manages the document. It does not include as extensive a set of annexes since many of the requirements documented in the PIP annexes are internal to MOD for the Station flights.

**Post Increment Evaluation** -This is a good opportunity to incorporate lessons learned from flights that are further along in the planning process or those that have already flown. Every organization is required to document and incorporate lessons learned.

### 15.3.6 Increment Planning

***Increment Planning begins at about I-18 months and continues until launch. This is the phase in which actual flight and increment products are produced.***

**On-orbit Operations Summary (OOS)** - This is a high level activity plan for an entire increment. High level activities are scheduled for a specific day of the increment but are not scheduled for a specific time. Few, if any details about the activity are provided. The OOS establishes the basis from which distribution of ISS resources is made by providing expected resource availability and environmental conditions throughout an increment, and by identifying constraints and critical events or time periods during an increment. The OOS is also the foundation for the development of the detailed Short Term Plan (STP), covered later in this section. Work on the OOS begins at about I-18 months and continues throughout the Increment Planning phase. The OOS is also updated during increment execution to reflect operations as they actually occur. The OOS is analogous to the Expedition Plan used on the Mir space station. There is no analogous shuttle product due to the short duration of shuttle missions.

**Joint Operations Planning Agreement (JOPA)** - This product covers only the periods during an increment when a Shuttle is docked to the Station and includes a detailed timeline for the joint shuttle/Station activities identified in the OOS. JOPA development starts at about I-12 months, in conjunction with Shuttle Flight Plan development. See Figure 15-2.

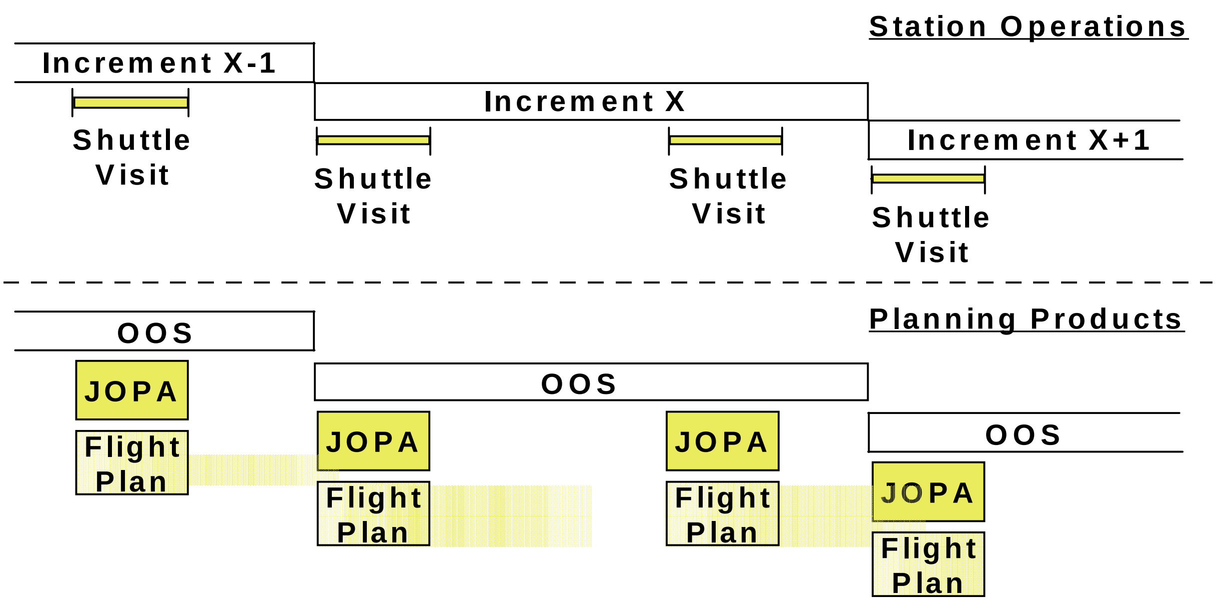


***Figure 15-2. JOPA timeframe***

**Flight Rules** - These are the guidelines for real time decision making. They are monitored and approved by the Flight Rule Control Board (FRCB) chaired by the Flight Directors. There are Generic, Increment Specific, and Flight Specific versions of the flight rules.

**Ground Rules and Constraints (GR&C)** - These are the guidelines used to create the OOS, STP and other planning products. They include rules for frequency of activities, vehicle constraints, communication requirements, etc. As with flight rules, there are both generic GR&Cs and increment specific GR&Cs.

**Operations Data File (ODF)** - ***This is the collection of procedures and reference material required to operate and maintain the ISS systems, payloads and attached vehicles. The ODF includes both paper and electronic material, but the emphasis is on electronic data.*** There are six major components to the ODF. They are as follows:

- Systems Operations Data File (SODF) - Includes the NASA, Canadian Space Agency (CSA) and Italian Space Agency (ASI) system procedures as well as any multi-element systems procedures
- Payload Operations Data File (PODF) -Includes U.S., Italian, and multi-element payloads procedures
- CSA PODF - Contains Canadian Payload procedures
- Russian Space Agency Operations Data File (RSA ODF) - Contains the systems and payload procedures for the Russian Orbital Segment (ROS)
- European Space Agency (ESA) ODF - Contains both systems and payloads procedures for the European element
- NASDA ODF - Contains both systems and payloads procedures for the Japanese element

**SODF** - ***The SODF is the repository of all the U.S. Space Station onboard and ground systems procedures.*** Procedures contain the necessary technical information compiled in a standardized format that the crew and ground controllers need in order to perform their jobs. Procedure authors gather information from various sources before writing a procedure. Once written, the procedure is validated and verified to ensure its safety and effectiveness. ***The development of procedures takes place in three cycles: Preliminary, Basic, and Final.*** The Preliminary cycle is worked from L-24 months to L-12 months and involves the initial development of the procedure. Once written and reviewed the procedure moves to the Basic cycle, where the majority of the validation occurs. The Basic cycle covers the time period of L-12 months to L-6 months. During the Basic cycle the procedure is refined by incorporating any new information that has become available. At the end of the Basic cycle, at L-6 months, the procedures must be contained within the U.S. SODF. The Final cycle is worked from L-6 to L-2 months. This is the last chance to change a procedure. After the Final cycle only critical change requests are accepted.

***The U.S. SODF contains six different types of procedures:***

- ***Activation and Checkout - Used for the activation or checkout of systems or components of systems.*** Activation of the APLU would be an example of this type of procedure
- ***Nominal - Used to carry out the normal day-to-day functions.*** One example is the setup of the early PCS laptop computer

- ***Quick Response - Used in the event of a failure to quickly safe the system within a very limited amount of time.*** One example would be a fire
- ***Malfunction - Designed to address system or equipment failures that require a diagnostic process,*** such as a procedure for dealing with a failed Multiplexer/Demultiplexer
- ***Corrective - Designed to bypass or overcome a failure condition***, such as a procedure for removal and replacement of a transducer
- ***Reference - Includes non-executable ancillary information used to ensure the successful execution of a procedure***. An example would be 1553 bus assignments or caution and warning event tables

**Integrated Operations Plan (IOP)** - This is really more of a tool to access and review many of the products discussed in this section. It provides on-line access via the Internet to operations products and schedules. The IOP is organized and developed by increment and includes access to the SODF, MITP, GR&C, and flight schedules. It is maintained by DO47, the Flight Planning and Tool Development Group. The Preliminary IOP is frozen at I-12 months, the Basic at I-6 months and the Final at I-2 months.

### 15.3.7 Increment Execution

This phase begins with the start of the increment. The planning products produced in this phase employ a "just-in-time" development philosophy to ensure the availability of up date plans and to minimize the need for frequent replanning.

**STP** - ***The STP is the detailed integrated schedule of activities to be performed during 1 week of Station operations.*** The STP includes all ISS activities, including systems and payload activities from all partners. In addition to crew activities, STP timelines also include automated onboard activities and ground controller activities, as well as ancillary data such as Station attitude and communications coverage data. Activities in the STP include all the information necessary for execution, including a reference to the procedure associated with each activity. The STP is somewhat analogous to a combination of the Shuttle Flight Plan and the Spacelab Payload Crew Activity Plan (PCAP). The differences between the STP and the shuttle products are that, while the Flight Plan and PCAP are paper products used for onboard execution, the STP is an electronic product used only for ground planning. However, the STP is used to derive the Onboard Short Term Plan (OSTP) which is used for onboard execution. The STP is developed the week prior to its execution and is based on the OOS which was developed prior to the increment (Figure 15-3). Development of the STP is performed by a team called the International Execute Planning Team (IEPT) which consists of planning personnel from each partner under NASA leadership.

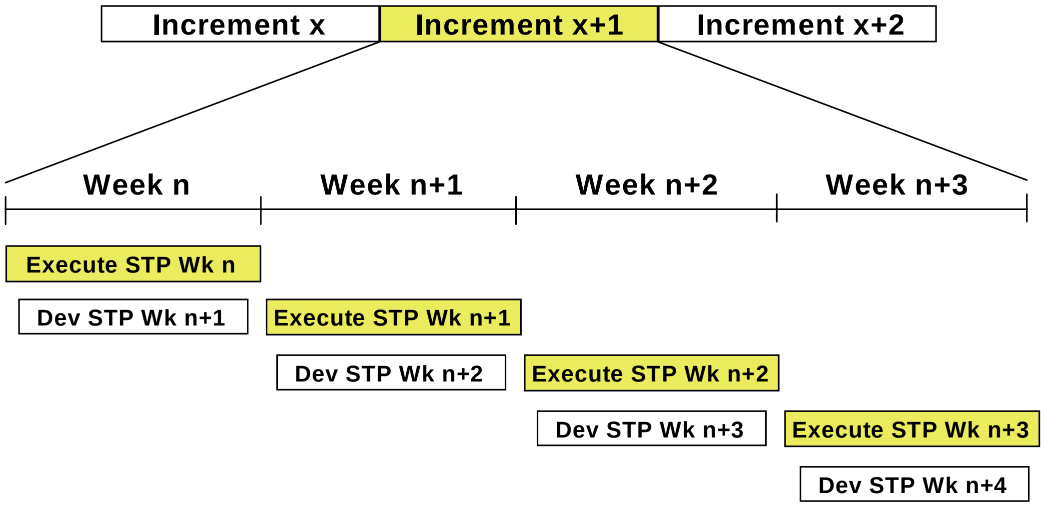


***Figure 15-3. Weekly STP development***

**OSTP** - ***The OSTP is the integrated plan which is viewed and executed onboard Station***. Since it is derived directly from the STP, the OSTP contains all activities to be executed, including crew, ground, and automated activities for the U.S. and IP Segments. The OSTP contains approximately 3 days of activities. At any given time, the OSTP contains yesterday's, today's, and tomorrow's activities, with uplink of new activities occurring daily. In addition to scheduled activities, the OSTP also contains "Jobjar" activities. These are activities which do not need to be performed at a specific time but can be performed at the crew's discretion. With the arrival of Timeliner software for the Command and Control Multiplexer/Demultiplexer (C&C MDM) on Flight 8A, the OSTP is also able to initiate automated activities at preplanned times without crew or ground involvement. Like the STP, the OSTP also contains ancillary data such as Station attitude and communication coverage data. ***The OSTP is viewed using an onboard laptop computer using software called the OSTP/ODF Crew Interface (OOCI).*** In addition to the OSTP, OOCI software is also used by the crew to view electronic procedures and other electronic documentation. ***After Flight 8A, OOCI also allows the crew to view and interface with any automated procedures that may have been implemented***. Ground controllers are able to view and interface with the OSTP on Mission Control Center (MCC) workstations using software called the OSTP Editor/Viewer (OE/V). OSTP and OOCI capabilities will be phased in during the assembly sequence. When all capabilities are available, the OSTP provides a very powerful planning and execution tool for the crew and controllers. Some of the capabilities that will be available are linking to procedures directly from the OSTP, statusing activities directly on the OSTP, filtering of activities, setting reminders of upcoming activities, and making notes and annotations directly on the OSTP. Also, using OE/V software, ground controllers will be able to keep track of onboard activity status with constant voice communication with the crew. The relationship between the OOS, STP, and OSTP is summarized in Figure 15-4.

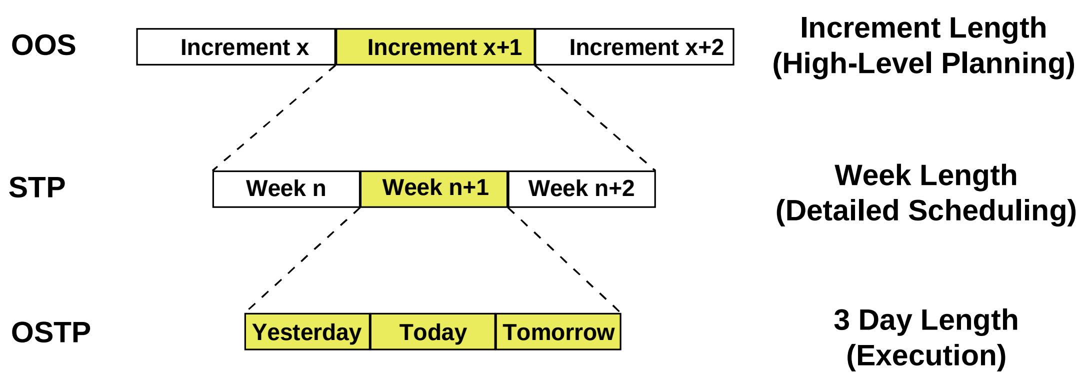


***Figure 15-4. Relationship between the OOS, STP, and OSTP***

## 15.4 Planning and Analysis Tools

While there are many tools available for the planning and analysis of station operations, there are several tools and products in particular which deserve special attention because of their widespread use and impact on operations.

### 15.4.1 The Integrated Planning System

Resource management is the process in which limited Space Station commodities, such as power, thermal rejection, communications bandwidth, etc. are divided up among various Space Station users. Systems onboard the Space Station are very interdependent, much more so than on Shuttle (for example, power is dependent on attitude, which may be driven by propellant supply, thermal concerns, or power needed).

In order to provide data on resources available, identify conflicts in resource allocation, and distribute Station resources, the Integrated Planning System (IPS) was developed. The IPS is an integrated collection of computer applications used for planning and analysis of Space Station operations. The primary users of IPS are flight controllers and planners developing the OOS, STP, and OSTP. IPS consists of the following six major applications

- Consolidated Planning System (CPS) - Used for generation and analysis of both ground and on orbit activity timelines and plans. CPS is used to assess the IDRD, generate the OOS, STP, and OSTP as well as performing real time and near-real time planning and replanning. CPS can schedule against multiple resources, as well as handle complex conditions and constraints, and is used for both ISS and Shuttle planning

- Consolidated Maintenance Inventory Logistics Planning (CMILP) tool - Used by ground controllers and planners for onboard inventory tracking, developing station resupply/return requirements, and for real time and near real time support of maintenance operations

- Flight Dynamics Planning and Analysis (FDPA) tool - Used by ground controllers and planners to provide high fidelity trajectory, attitude, propellant consumption, and communications coverage analysis

- Procedures Development and Control (PDAC) tool - Used by ground controllers to develop and configuration manage operations procedures, develop onboard executable procedures via the Timeliner compiler interface, and distribute procedures electronically
- Resource Utilization Planning and System Models (RUPSM) tool - Models the ISS Electrical Power System (EPS), Thermal Control System, and Environmental Control and Life Support System systems. Using RUPSM, ground controllers can analyze and plan usage of ISS electrical, thermal, and life support resources to support timeline development and monitor system performance in real and near real time
- Robotics Planning Facility (RPF) - Provides software tools to model robotics systems, including the Space Station Remote Manipulator System (SSRMS). RPF is used as a robotics design, analysis, and training tool and provides real time and near real time robotics operations support
- ISS MOD Avionics Reconfiguration System (IMARS) - IMARS is the central repository for ISS MOD reconfiguration products and provides the software tools required for processing reconfiguration data. IMARS produces Mission Build Facility (MBF) utilization files from the Standard In and command/telemetry products for the MCC and Portable Computer System (PCS) from MBF Standard Out. It also provides flight software and data configuration management and serves as a central repository for command files, data load files, caution and warning limits, and Standard In and Standard Out files

## 15.5 Inventory Management

Due to the volume of articles onboard Station, and the fact that Station will be on orbit continuously for at least 15 years, the need arises for a system of tracking the location and status of items that have been stored on board. The Inventory Management System (IMS) fulfills that purpose.

The Inventory Management System, together with detailed logistics planning, provides a process used to ensure that the right items are in the right place at the right time. To perform this task, plans and processes are developed which ensure the continued support of the ISS core systems. Mission manifesting and transfer of items to the Kennedy Space Center (KSC) are also supported.

Logistics and inventory management starts years before a flight and determines who sends what items to the ISS, what vendors are used during the procurement process, and how items will be repaired. This is extremely important because it is necessary to ensure that the right items are sent to, maintained on, and returned from the ISS at the right time. A current status and a forecast for the future availability of inventory is essential. It is necessary to know what is broken in order to fix it.

Inventory is affected by the manifest of each flight. The ISS uses the Inventory Storage File to determine exactly what is onboard. Inventory includes items pertaining to:

- Crew Support - Includes clothing, food, and personal items

- Station Support - Includes spares, repair parts, consumables, technical data and documentation, support equipment, etc.
- User Support - Includes items required to support customer/user for payloads and their associated support items, and consumables including fluids and gases. It also includes returning experiment products, specimens, and disposal of waste materials

***The inventory on the ISS is managed by the Inventory Management System (IMS). IMS is a software application that resides on onboard laptop computers, so updated inventory is available Station wide. Updates to the inventory can be made via the keyboard, Graphical User Interface (GUI) or bar code reader.*** IMS provides capabilities for crew queries, displays, editing of locations, keeping track of quantities, changes in operational status, changing hazardous codes, keeping notes, etc. It also creates a change/update log to track inventory activities.

Two scheduled inventory audits are planned for the Station crew on orbit. The first allows sufficient time for the necessary items to be manifested into the MPLM and the second is done closer to launch for items to be manifested into the middeck lockers. The ground tracks everything else. One thing to note is that food is not tracked but is in the database for volumetric purposes. There is a set resupply regardless of what has been consumed.

Resupply and Return Analysis is another part of Inventory Management, used to evaluate the capability to supply logistics support resources for on-orbit systems. Weight and volume requirements of Orbital Replacement Unit (ORU) spares, repair parts, support equipment, tools, etc. all have to be evaluated. Decisions must be made concerning everything from the number of crewmembers allowed on a flight to alternative logistics carriers that could be used. Unfortunately, due to constraints science requirements may be impacted by system maintenance requirements. There may also be times when a payload item is moved to another flight or scheduled maintenance activities have to be postponed, all due to changes in the manifest.

As can be seen the manifest is an ever changing list of items dependent upon the IMS to ensure crewmembers have what they need, when they need it, in order to sustain the ISS and themselves.

## 15.6 Summary

What is immediately obvious from this brief overview is that the ISS planning and operations process is a very complex web of simultaneous activities and products, all of which are in various stages of maturity at any given time. There is no clear starting and ending point that is analogous to a single space shuttle mission. Planning for a particular day, week, increment, and year on ISS all occur simultaneously with on-orbit operations. Perhaps the best way to summarize this is to look at what could be an individual day in the life of the ISS program.

On this particular day, a crewmember pulls up the OSTP on a laptop, and views the activities that are scheduled for the day. The first scheduled activity in the timeline is performing a minor maintenance task. Using information provided in the activity, the crewmember pulls up the necessary procedure, which is contained in the SODF, and begins to collect the necessary tools and materials, an easy task since their location has been recorded and stored within the IMS.

Meanwhile, ground planners are converting STP data into OSTP records in preparation for uplink to the crew. At the same time, other ground controllers are busy generating data in IPS applications in preparations for next week's operations. One EPS controller, for example, uses RUPSM to predict exactly how much power is available at any given time during the week. This prediction is fed, in part, by trajectory and attitude data that was generated by FDPA as part of OOS development in preparation for the increment. Later in the week, the Operations Planner uses CPS to take this predicted data, along with activities scheduled during OOS development, to schedule the activities appropriately into next week's STP.

While the OOS for the current increment is in use, development and refinement of the OOS for the next increment would be proceeding. Again using tools available in the IPS, as well as increment requirements from the IDRD, data and activities are generated to help define everything that needs to get done during the increment. Also, ground controllers are busy writing new procedures related to the activities for the increment and logistics personnel are working out the shuttle manifest to get the needed equipment onboard.

This very brief and simplified scenario provides an idea of the complexity of the Station planning and operations process. Of course, the actual processes are much more complicated and require a tremendous amount of integration among many different organizations, both U.S. and IPs, to successfully plan and perform Station operations.

# Questions

1. What planning product represents the integrated plan to be viewed and executed onboard Station, and contains the specific activities that will be performed by the onboard crew?
2. What is the purpose of the Station Operations Data File (SODF)?
3. During what time period is the Short Term Plan (STP) developed, and how long is the operations period the STP covers?
4. What tool will be used by onboard crew and ground controllers to track location and quantity of equipment and supplies onboard ISS?
5. Which of the following provides on-line access via the Internet to operations products and schedules?
    a. On Orbit Summary (OOS)
    b. Onboard Short Term Plan (OSTP)
    c. Mission Integration Plan (MIP)
    d. Integrated Operations Plan (IOP)
6. Which of the following is not a phase of ISS planning and operations?
    a. Strategic Planning
    b. Tactical Planning
    c. Short Term Planning
    d. Increment Planning
    e. Increment Execution
7. Which collection of software applications is the primary tool used by the Mission Operations Directorate (MOD) to perform Space Station planning and analyses?
    a. Consolidated Planning System (CPS)
    b. Station Operations Data File (SODF)
    c. Mission Operations Directorate Engineering and Logistics System (MODELS)
    d. Integrated Planning System (IPS)